Interactive Pedestrian Indoor Localization

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Abstract

This thesis focuses on the improvement of pedestrian indoor localization systems through user interactions. First, a hybrid localization system for mobile devices which relies on multiple sensors is developed. It forms the basis for the design and implementation of interactions between the user and the system that aim to increase the localization accuracy. Finally, a simulation is conducted to evaluate the system's performance. It shows that localization accuracy can in fact be improved in case the user cooperates.

Keywords: indoor localization; pedestrian navigation; user interaction

1 Introduction

While GPS enables location-based services outdoors, no similar technology exists that can be used inside buildings, despite a lot of research and technological improvements in recent years. This thesis consolidates work that has been done in previous pedestrian navigation projects and introduces explicit user interaction as a new approach to improve indoor localization.

In: M. Gäde/V. Trkulja/V. Petras (Eds.): Everything Changes, Everything Stays the Same? Understanding Information Spaces. Proceedings of the 15th International Symposium of Information Science (ISI 2017), Berlin, 13th–15th March 2017. Glückstadt: Verlag Werner Hülsbusch, pp. 293–296.

2 Hybrid indoor localization

State-of-the-art pedestrian indoor localization systems rely on a multitude of sensors to estimate an accurate position and are hence called hybrid localization systems. Just like previous projects (Ebner et al., 2015; Hilsenbeck et al., 2014), the solution that was created as the first part of this thesis uses Wi-Fi fingerprinting for absolute positioning, as well as inertial sensors for relative measurements. In combination with an existing graph-based environment model (Ohm, Müller & Ludwig, 2015), the sensor information is then fused by a particle filter in order to estimate the user's position.

3 Adding user interaction

The deliberate addition of user interaction into the localization process is the main contribution of this thesis. Since the system is intended to be used as part of a pedestrian navigation application on smartphones, it can rely on the user to provide information about his whereabouts.

Figure 1 shows examples of how the user can interact with the system by entering the name of a room or selecting a nearby landmark. The interactions can be triggered by the system at various occasions during the localization process, e.g. if the uncertainty exceeds a predefined threshold.

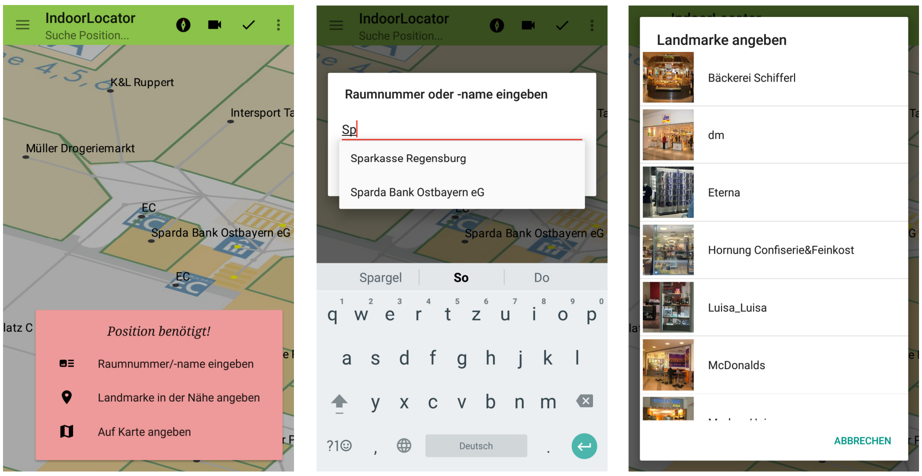

Fig. 1 The user interface of the localization system

4 Evaluation

To evaluate the system and the influence of user interactions, a simulation based on real sensor data was conducted. The data was collected in a shopping mall in Regensburg on 15 randomly selected test routes with a length between 65 and 280 meters. Various user interaction profiles were created from a combination of different factors: The input accuracy was evaluated at five levels from a theoretically perfect user to a very inaccurate user. Similarly, the absolute input error was varied. Finally, the willingness to cooperate was simulated, from an immediately cooperating to a completely uncooperative user. Based on these profiles, the following hypotheses were tested:

- H_1: The more accurate the user input, the lower the position error.
- H_2: The lower the absolute input error, the lower the position error.
- H_3: The higher the cooperativeness, the lower the position error.

For every configuration, 1000 runs were simulated on each of the test routes. Localization performance was measured by the mean distance to ground truth, averaged over all runs of a configuration.

Since the data is not normally distributed and heteroscedastic, non-parametric Kruskal-Wallis tests were performed. Post-hoc Dunnett-Tukey-Kramer tests showed significant differences between every single combination of configurations on an alpha level of .05 for the first 2 hypotheses. Hypothesis 3, however, cannot be accepted completely. While it does make a difference whether the user interacts or not, the time of interaction does not significantly influence the position error in most cases.

The results also show that a good initial location is very important for accurate localization, even if no further interaction takes place. It follows that it is better to have a user interact only once accurately at the beginning, rather than multiple times, but inaccurately.

5 Conclusion and outlook

The evaluation has shown that the localization performance can indeed be improved if the user gives reasonably accurate input. However, cooperation was simply assumed here and needs to be tested in future studies.

Currently, the system is being integrated in a pedestrian navigation system, which provides more context and therefore more information to work with. In the end, even though user interaction is the focus of this thesis, it should be used sparingly in order not to overwhelm the user.

References

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